NASA Office of Technology Transfer

John C. Stennis Space Center

Vertical Fluorescence Profiler May Be First of Its Kind

A fully submersible oceanographic vertical profiler for in situ measurements

Photos of FLIPPER

The Fluorescence Lifetime Profiler of Photochemical Efficiency in Real time, or FLIPPER for short, was developed by Ciencia, Inc., of East Hartford, CT, under a NASA Stennis Space Center Small Business Innovation Research (SBIR) contract. FLIPPER was designed to assist in the understanding of the global processes controlling the time-varying fluxes of carbon and associated biogenic elements in the ocean. The prototype was developed as a fully submersible oceanographic vertical profiler for *in situ* measurements. Besides meeting NASA's needs the technology has potential application in the medical, food processing and pharmaceutical industries.

The FLIPPER prototype was developed as a fully submersible oceanographic vertical profiler for *in situ* measurements. Its purpose is to study phytoplankton and related issues of photosynthesis and primary production. The prototype is unique in that it can measure in real time the structure of chlorophyll concentration and of phytoplankton photochemical efficiency in the water column. A frequency-domain fluorometry approach to measure chlorophyll fluorescence lifetimes enables measurement of photosynthetic parameters.

One of FLIPPER's enabling technologies is a compact, low-power instrument for measurement of *in vivo* chlorophyll fluorescence lifetimes. Other elements of this new technology include a unique optical design, development and fabrication of a housing rated to a depth of 300 meters, miniaturization of the electronics and a redesign of the power supply to enable extended battery operation.

HOT Points

- **Includes frequency-domain fluorometry approach.**
- **Low power instrument rated to a depth of 300 meters.**
- **Extended period of operation.**
- **Permits for the first time direct determination of in vivo chlorophyll fluorescence quantum yield in situ.**
- **Broad based applications include medical, food processing and pharmaceuticals industries.**

WHY FLIPPER IS IMPORTANT

A critical objective in oceanography is the understanding of global processes that control the time-varying fluxes of carbon and associated biogenic elements in the ocean. Currently the most practical approach to determining carbon flux distributions on a global scale is remote sensing by satellite. Since the major carbon flux in the ocean is due to photosynthesis by phytoplankton, there is considerable interest in remote sensing of phytoplankton productivity in the oceans through ocean color or chlorophyll fluorescence measurements. Determination of ocean column productivity from satellite-based observations of surface layer color, however, is far from ideal. The correlation between the surface or the water column chlorophyll and the water column integrated primary productivity is not reliable.

The algorithms used require knowledge of phytoplankton physiological parameters and of the biological structure of the water column, information that has been difficult to obtain and that is accessible only from *in situ* measurements. Thus, determination of ocean primary production from satellite remote sensing requires adjunct *in situ* sensors to generate the necessary algorithm input parameters.

Previous vertical profiling methods are inaccurate and confusing. Current *in situ* instruments based on chlorophyll fluorescence intensity cannot provide accurate information on chlorophyll concentration; the quantum yield of chlorophyll fluorescence *in vivo* is variable, and intensity alone does not provide any information at all on photosynthetic status. The FLIPPER prototype permits for the first time direct determination of *in vivo* chlorophyll fluorescence quantum yield *in situ*. This is an essential parameter in the study of ocean and coastal ecosystems, one that has been shown to be inversely related to the rate at which phytoplankton biomass is formed. The development of FLIPPER is an important advance for biological oceanographic research, for phytoplankton ecology studies and for ground truth of primary production estimates made from satellite ocean color measurements.

TARGET MARKETS

FLIPPER will address NASA's oceanographic needs, as well as other applications include monitoring of photosynthetic parameters in marine phytoplankton, oceanographic, estuarine, limnological and riverine studies, environmental monitoring of phytoplankton populations, ocean optical properties research and fisheries and ecosystem studies.

Additionally, the technology created for FLIPPER has broader potential applications. For example, the low-power, compact frequency-domain electronics has potential applications to frequency-domain fluorometry for biological research and high-throughput drug discovery. Another direct application is frequency-domain photon migration (FDPM) for clinical diagnostics (e.g., brain oxymetry) and for non-invasive, real-time, on-line process monitoring (e.g. in the food and pharmaceutical industry). Precision farming, non-invasive clinical instrumentation and analytical instrumentation for food safety testing and environmental analysis are other application areas.

FUTURE OF FLIPPER

Based on the core technological development of FLIPPER, Ciencia has entered into two commercialization agreements that represent non-equity investments in R&D and engineering services directed at new product development.

Ciencia has received a significant investment from HTS Biosystems of Hopkinton, MA, for a product development effort that will incorporate frequency-domain technology developed in this SBIR to instrumentation for high-throughput drug discovery.

In addition, Ciencia has entered into another product development agreement with an international company for development of a sensor for on-line process analysis of powder mixtures in the pharmaceutical industry. The feasibility study funded by this commercialization partner has been completed and development of a system for beta site testing is underway. These activities also represent a significant commercial investment in the technology

WHY SBIR?

"This project is exemplary of the goals of the SBIR program," said Dr. Salvador Fernandez, president of Ciencia, Inc. "On one hand we have been able to provide NASA with unique, novel technology, essential to meeting its Earth Science Enterprise mission, while at the same time creating core technology that has enabled us to develop new products for very different applications, such as drug discovery and process analysis in the pharmaceutical manufacturing industry."

SBIR is a highly competitive multi-phase program that provides small U.S. businesses with federal funds reserved for conducting serious research and development. Phase I is the start-up segment with awards up to $70,000; if chosen, Phase II awardees are granted up to $600,000 to conduct research and development for two years. The SBIR Program at Stennis Space Center is managed through the

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